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Form Approved
OMB No. 0704-0188

[illegible] to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson [illegible] Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

[illegible]ORT DATE

3. REPORT TYPE AND DATES COVERED
ANNUAL 01 Jan 92 TO 31 Dec 92

4. TITLE AND SUBTITLE
AN INVESTIGATION OF THE NEAR EARTH SPACE ENVIRONMENTS

5. FUNDING NUMBERS
F49620-92-J-0196
61102F
2311
AS

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8. PERFORMING ORGANIZATION REPORT NUMBER
AFOSR-TR [illegible] 0261

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10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release;
distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Progress has been made in four areas: (1) Mapping the different regions of the magnetosphere into the ionosphere under varying solar wind conditions. This research is relevant to future USAF operational systems needs in that the environment experienced by a spacecraft differs greatly depending on the region being transited. (2) Understanding the convection surge mechanism in the magnetotail. (3) Determining the plasma source region for dayside auroral emissions through coordinated satellite imagery and particle data. (4) Creating a new interpretation of dayside auroral transients, involving directly driven ionospheric response to magnetosheath changes.

93 5 12 150

93-10703

14. SUBJECT TERMS

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
(U)	(U)	(U)	(UL)

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89)
Prescribed by ANSI Std. Z39-18

Annual Progress Report for 1992 on AFOSR Grant F49620-92-J-0196

Ching-I. Meng, Principal Investigator

The Johns Hopkins University Applied Physics Laboratory

January, 1993

In 1992 we made progress on several fronts: (1) Mapping the different regions of the magnetosphere into the ionosphere under varying solar wind conditions; (2) Understanding the convection surge mechanism in the magnetotail; (3) Coordinated satellite imagery and particle data to determine the plasma source region for dayside auroral emissions; and (4) Creating a new interpretation of dayside auroral transients, involving directly driven ionospheric response to magnetosheath changes. The first line of research is particularly relevant to future USAF operational systems needs in that the environment experienced by a spacecraft differs greatly depending on the region being transited. We discuss each of these research areas in turn in the sections that follow.

In addition to the original research carried out under this grant, we have been providing a valuable service to the space physics community in providing an online DMSP particle-identification data base. Since our efforts to accurately identify regions of precipitation seen at low altitude have become internationally recognized as the best available, many researchers in the field seek our help in identifying the types of auroral particle precipitation observed and the high-altitude sources thereof. The neural network online data base provides a means for any researcher at almost any university to access this information. Since the inception of the data base, over 1500 individual requests from about 3 dozen individuals at about 2 dozen different research institutions have made use of the data base in their own work (some extensively!).

Moreover, work carried out under this AFOSR grant is enabling the collaboration with two graduate students at the University of Alaska, Fairbanks. These students, Joe Minow and Gerard Fasel are in frequent contact with staff members at APL, particularly Dr. Patrick Newell, and are using some of the resources made available through this grant, such as DMSP spectrograms.

Projecting Magnetospheric Plasma Regimes into the Ionosphere Under Varying Solar Wind Conditions

By examining the types of precipitation one observes at low altitude, and by comparison with the field-aligned population observed at high altitude, one can infer the source region of the precipitation [*Newell et al.*, 1991 *a; c*]; and, with data from enough satellite passes, construct a precipitation map [*Newell and Meng*, 1992]. Such massive statistical work relies on automated identifications, as documented previously [*Newell et al.*, 1991*b*]. To advance our understanding of the low-altitude satellite environment, the projection of magnetospheric regions into the dayside ionosphere was studied for dependency on solar wind parameters. It was found that the solar wind kinetic pressure, p, dramatically affected the map of magnetospheric projections. Under the contraint that $p \geq 4$ nPa (yielding $\langle p \rangle = 5.9$ nPa) the area of the cusp (magnetic latitude times magnetic local time extent) was 4.83 degree-hours; whereas under the constraint that $p \leq 2$ nPa (yielding $\langle p \rangle = 1.5$ nPa) the cusp area was only 0.95 degree-hours. The ionospheric footprint of the low-latitude boundary layer was similarly affected. Various possible correlations of p with other solar wind variables including n, v, and $|B_z|$ proved unable to account for the pressure effect; instead it was p itself which had the most striking influence. What remains unclear is the actual physical mechanism for the pressure effect. The obvious possibility is that under high-p conditions there is increased direct solar wind plasma penetration of the magnetopause in the manner suggested by various proponents of impulsive penetration models. An alternative which we find more promising is that regardless of the original Interplanetary Magnetic Field (IMF) strength, a high-p solar wind leads to a large compression factor for the magnetosheath field; which is the field actually in contact with the magnetosphere. From this latter viewpoint the chief effect of high particle pressure is simpıy to enhance the effectiveness of the magnetosphere-IMF interaction.

Figures 1-3 show the ionospheric maps under normal, low, and high solar wind conditions.

Understanding the Convection Surge Mechanism in the Magnetotail

During the 1991-1992 period we carried out theoretical studies of the convection surge convection surges that occur in the near-Earth magnetotail after substorm onset. Convection surges consist of transient enhancements of the east-west electric field that coexists with a modification of the near-Earth magnetotail magnetic field from tail-like to nearly dipolar. A number of codes have been produced by other authors to model these dipolarizations. The time dependence of the dipolarizations are conducive to the loss of adiabaticity of certain particles, depending on their species, initial location, and energy. Single particle codes have been used to conclude that the injection boundary that is observed at near-geosynchronous altitudes (consisting of field-aligned Hydrogen and Oxygen distributions up to a few keV's) can be identified with the boundary that separates the inner magnetospheric regime where the particles respond adiabatically to the dipolarization from an outer regime where adiabaticity does not hold. These models involve very complicated magnetic field geometries and very involved single particle trajectory calculations. Therefore, they cannot be used to infer the behavior of the entire distribution function. We have modified the computer code originally produced by *Mauk* [1986] to address the response of the entire distribution function. The main modification consisted of the explicit consideration of the breakup of adiabaticity that occurs during convection surges. Our results (*Sánchez et al.*, GRL, in press) show that, contrary to the conclusions drawn from single-particle calculations, the near-Earth injection boundary cannot be interpreted as the boundary between adiabatic and non-adiabatic regimes. Other processes must be acting cooperatively or alternatively to produce the injection boundary. One that has not been considered heretofore is the presence of intense, short-lived magnetic field-aligned electric fields produced during dipolarizations. These electric fields can play an important role in the modification of particle distributions. We are currently developing a new computer code that explicitly takes the generation of field-aligned electric fields into account.

Coordinated Satellite Imagery and Particle Data to Investigate the Dayside Aurora

Because of the obvious imaging problems during daylight local times, auroral behavior on the dayside has been less investigated than the nightside. On the other hand, identification of plasma regimes on the dayside using low-altitude satellite data has become much more sophisticated in recent years, creating an opportunity for making progress in understanding the dayside aurora. Our research on this topic proceeded in two ways: (i) Using the Polar BEAR ultraviolet imager to image the dayside even under full sunlight, coordinated with nearly simultaneous

DMSP passes to provide particle information; and (ii) Using the DMSP optical imager in austral winter to image dayside aurora at times when the latter is in darkness.

The objective of the first approach was to determine the source region of auroral emissions in the prenoon oval. We compared particle observations from the DMSP F7 satellite during dayside auroral oval crossings with approximately simultaneous Polar BEAR 1356-Å images to determine the magnetospheric source region of the dayside auroral oval. The source regio. is determined from the Defense Meteorological Satellite Program (DMSP) particle data, according to recent work concerning the classification and identification of precipitation source regions. The close DMSP/Polar BEAR coincidences all occur when the former satellite is located between 0945 and 1000 MLT. We found instances of auroral arcs mapping to each of several different regions, including the boundary plasma sheet, the low-latitude boundary layer, and the plasma mantle. However, our results indicated that about half the time the most prominent auroral arcs are located at the interfaces between distinct plasma regions, at least at the local time studied. Thus arcs often demarcate boundaries between distinct magnetospheric source regions.

The second approach we used on this problem was using the DMSP optical imager during austral winter to image the near-noon auroral oval. DMSP F6 and F7 imagery was combined with particle data from the same satellites to investigate the relationship of the mid-day auroral gap [*Meng*, 1981] to the cusp. This is a topic particularly worth revisiting in light of the recent acquired ability to reliably distinguish the region of truly magnetosheathlike plasma at low altitude (the "cusp proper"). Preliminary results show that while the gap is not precisely coincident with the cusp --

parts of the gap lie in precipitation which is not magnetosheathlike and simply lack electron acceleration -- the original hypothesis of *Meng* [1981] has substantial validity. The cusp generally does lie within the gap, although some caveats such as occasional thin arcs just equatorwardward of the cusp, need to be considered. When this research is in a more mature form it will be submitted to JGR.

A New Interpretation of Dayside Auroral Transients

Most researchers agree that ionospheric convection is controlled by the magnetosheath B_y and B_z and by sheath flows. However transient changes in convection flows are nonetheless generally attributed to spontaneous transient changes in the merging rate. Noting that changes in the magnetosheath field are endemic, we have proposed [*Newell and Sibeck*, 1992] an apparently obvious but overlooked paradigm: ionospheric transients are directly driven by changes -- not necessarily transient -- in the magnetosheath. For example, an increase in the sheath B_y component drives flows faster eastward or westward; while a decrease in the magnitude of B_y leads to a transient propagating largely poleward. Auroral transients are caused by the velocity shears associated with changing convection patterns. This new model, in which merging is continuous, and sheath transients directly drive ionospheric transients, easily overcomes a host of difficulties contained in the old model. For example, auroral transients frequently convect through the pre-existing optical cusp; whereas if there has been no change in the sheath parameters any new merging should not move relative to the equally open cusp field lines. Indeed, if sheath conditions are unchanged, merging additional lines does not change their motion; it simply means that more flux tubes exhibit the same motion. It is because of the variability in the sheath parameters that variability in ionospheric convection is imposed. The sources of such sheath variability include intrinsic IMF variations; variations created at the bowshock; and compression of the sheath field by a variable plasma pressure.

Plans for 1993

Many of the projects discussed above are ongoing; some are in fact just getting into peak activity. Specifically, the main line of research, determining the ionospheric projection of magnetospheric source regions continues apace; there is much work to be done on how varying solar wind parameters affect this mapping. Likewise work on imaging dayside auroral activity is ongoing; with the DMSP imager and particle precipitation data in the austral winter providing important insights into the relationship between auroral and magnetospheric topology. Work on the convection surge mechanism is not yet completed; while a new area of substorm research combining the Goose Bay Radar and DMSP particle and drift observations has been opened up. Controversial work on understanding the relationship between magnetosheath transients and auroral transients is also planned for 1993. The research prospects for 1993 appear inviting.

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